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A pilot home-based early intervention study to improve the mathematical skills of young children

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Abstract

Children who come from low socioeconomic backgrounds and children with learning disabilities are found to be at risk for future failure in mathematics. Even though the mathematics scores increases over time the achievement gap remains between the various ethnic and socioeconomic groups. One way to prevent this failure is to identify the students who are at risk and provide them with effective early intervention. This study reports the results of a pilot early mathematics intervention study focusing on two Turkish families in the US. In this single-subject research, a multiple probe technique was used in order to examine the impact of the SRA DLM Math Pre-K CD-ROM in combination with parent scaffolding on young children's number sense skills. Two parent-child dyads participated in this study. Two semi-structured interviews were conducted with the parents before and after the intervention. The child participants received 3 Mathematical Curriculum Based Measure (CBM) every week to monitor their progress. Building Blocks Assessment was used to identify whether children were able to generalize the number sense skills developed during work sessions in different settings. This measure was administered both before and after the intervention.

This study demonstrated that children's and parents' use of a software program where they work collaboratively at home resulted in increased number sense skills. These results were interpreted in the context of socio-cultural theory. The parents displayed different strategies during the mathematics work sessions, reflecting their own feelings about mathematics and technology.

Keywords: Early intervention; Mathematics; Single-subject; Educational technology; Parent-child collaboration

Introduction

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²This manuscript is adapted from the pilot study of the author's dissertation research.

It is commonly accepted that children in the US are not achieving satisfactorily in mathematics. (Geary, 1994; National Center for Education Statistics [NCES], 2003; Stedman, 1997). This fact is particularly true for students from lower socioeconomic backgrounds and children with special needs (Griffin, Case, & Siegler, 1994; Klein & Starkey 2004). According to the National Assessment of Educational Progress Reports (2005), while the average mathematics achievement scores of U.S. fourth-graders increased by 25 points and those of eighth-graders by 16 points between 1990 and 2005, the apparent achievement gap among various ethnic and socioeconomic groups remained. This paper will specifically focus on the experiences of low-income Turkish families with young children in the US.

According to *Children's Reading and Mathematics Achievement in Kindergarten and First Grade* (NCES, 2002), young children from lower socioeconomic groups demonstrated scores consistently lower than the national average. There is clear evidence that many of the students who are failing at math have been identified as having a learning disability (Bender, 2001; Fletcher, Lyon, Barnes, Stuebing, Francis, Olson, Shaywitz, & Shaywitz, 2002; Geary, 1999). Research suggests that mathematics disabilities manifest themselves before formal schooling starts and that such problems can be prevented with early identification and by providing meaningful intervention at an early age for those who are at risk (Berch, 2005; Gersten, Jordan, & Flojo, 2005; Mazzocco & Thompson, 2005). Even though most pre-school programs provide limited organized learning experiences, there is no commonly accepted curriculum for mathematics, science, and technology in pre-school programs. How to teach these subjects to young children remains one of the continuing issues of early childhood education (Bowman, 1998).

This paper reports the results of a pilot study demonstrating the effectiveness of an early mathematics intervention program. In the original study, the assumption was that not only would the intervention directly impact the children's skills, but by providing a home-based intervention, there would be increased mathematics awareness within the families, who consequently would be able to facilitate children's mathematical skills. It was expected that this intervention would help young children at risk for LDs achieve accelerated number sense skills through parent scaffolding by means of mathematics software.

Nature of the Problem

This study applied socio-cultural theory as a framework for analyzing the nature of the proposed problem and also in the design of the mathematics intervention for young children at risk for LDs. Professionals from fields such as psychology, linguistics, ethnography, and education have

been developing theories to understand how children learn. The *socio-cultural theory* attributed to Vygotsky articulates learning as a product of interaction among interpersonal (social), cultural-historical, and individual factors (Massey & Walford, 1998; Schunk, 2004). American researchers have contributed to the theory by introducing *scaffolding* into the framework of tutorial interactions among adults and children (Wood & Wood, 1996) and also a new model for apprenticeship in everyday, practical knowledge (Bliss & Askew, 1996).

A significant number of studies using socio-cultural theory as a framework to demonstrate the positive impacts of mediation and scaffolding, especially on language use and acquisition, can be located in the literature (Anton, 1999; Bliss & Askew, 1996; Coufal, 2002; De Guererro & Villamil, 2000; DiCamillia & Anton, 1997). The use of socio-cultural theory can also lead to practical and theoretical progress in the mathematics education of young children with disabilities (Goos, Galbraith, & Renshaw, 2002).

Early Intervention & Assessment in Mathematics

Several sources refer to the need for improving the mathematical abilities of American children (Geary, 1994; Stedman, 1997). The National Commission on Mathematics and Science Teaching for the 21st Century bases the future well-being of the United States on how well students are educated in mathematics and science. The commission's report confirms that U.S. children do not receive high-quality mathematics and science education that is able respond to the demands of the new century. To remedy this situation, the committee suggests establishing a system that continuously improves the quality of K-12 mathematics and science education (Glenn Commission, 2000).

A study of tenth-grade students who were not able to pass state English and math proficiency exams found that these students had already attained inadequate achievement scores in the early years of elementary school and that the majority of them had been struggling academically throughout their educational careers. Moreover, most of these students came from low socioeconomic status families (Nichols, 2003). Popham (1999) explains this situation as a function of mismatch between standardized tests and low-income students' out-of-school environments. The findings of Klein and Starkey (2004) demonstrate that socioeconomic differences between families create a wide gap in the informal mathematics knowledge of various young children. This gap includes numerical concepts and arithmetic reasoning in addition to lack of knowledge in the other areas of mathematics. Derived from these research findings, the intention of this dissertation is to improve young children's mathematical abilities by increasing mathematical activities between parents and children in an out-of-school context.

Given the importance of mathematics in children's future school and adult lives (Glenn Commission, 2000) and the role of socioeconomic status in learning disability (LD) placement (Blair and Scott 2002), it is crucial from a prevention standpoint to offer specific academic interventions for young children who face disadvantages (Blair & Scott, 2002; La Paro&Pianta, 2000; Nichols, 2003). Research has shown that pre-kindergarten assessments are predictive of future school success and that well-planned early intervention makes a significant impact (La Paro&Pianta, 2000; Ramey & Ramey, 1995).

Ramey and Ramey's experimental study (1995), the Abecedarian Project, confirmed the positive outcome of early intervention on children who are considered high-risk. In comparison to the control group, the treatment group began to show superior cognitive development by the ages of 24 and 36 months. While almost half the control group students were placed in special education classrooms by the age of 15, only 12% of the treatment group needed special education. The treatment resulted in higher scores in IQ, reading, and math. Fuchs (2005) states that preventive studies are necessary in the area of mathematics disability. It is recommended that these studies examine the efficacy of beyond whole-class prevention and provide information on various successful and feasible tutoring designs (Fuchs, 2005).

A recent study involving 564 first-graders, 127 of whom were at risk for mathematics difficulty, demonstrated the preventative effect of early intervention. After receiving tutoring three times a week for 16 weeks, the experimental group's at-risk students exceeded the control group's at-risk students in computation, concepts/application, and story problems. Their performance was equivalent to the non-at-risk student group. Preventative tutoring resulted in a 35.64% reduction in the prevalence of mathematical disabilities (Fuchs, Compton, Fuchs, Paulsen, Bryant, &Hamlett, 2005).

In compression to area of reading only a small group of researchers has studied valid measures of mathematical abilities of young children. In the area of LDs, curriculum-based measures (CBM) are valuable because a) they offer a different way to assess students; b) they inform educational practices and thus result in improved instruction; c) they focus on relevant variables; and d) assessment takes place when problem behaviors occur . An initial review of literature reveals two curriculum-based measures of mathematical performance for young children. The first one was developed for 4-year-old pre-schoolers (Vanderheyden, Broussard, Fabre, Stanley, Legendre, &Crappell, 2004), while the second one was developed for first-grade students (Clarke & Shinn, 2004). The CBM developed by Clarke and Shinn will be used as a weekly progress monitoring tool for this study.

Lack of Consensus on an Early Math Curriculum

The NCTM states the importance of teaching mathematics at an early age (National Council of Teachers of Mathematics [NCTM], 2000). In fact, most children are ready to learn about mathematics, science, and technology before they begin formal schooling (Elkin, 1998). Nearly all children who attend a pre-school program receive some type of mathematics education (Bowman, 1998). In order to increase the quality of mathematics education, researchers recommend using the standards provided by the NCTM (Baroody, 2004; Clements, 2004; Klein, Starkey, & Wakeley, 1998). However, there is no commonly accepted curriculum for mathematics in early childhood education (Bowman, 1998).

Promise and Concerns of Technology

The use of technology in educational settings has been expanding quickly (Langone, Malone, & Kinsley, 1999). Research findings show that the gap between technological opportunities provided to young children at high-poverty schools and at low-poverty public schools is decreasing. For children from low socioeconomic backgrounds, schools are still the primary place where they have access to computers (Judge, Puckett, & Cabuk, 2004).

The appropriate use of technology has benefits for children with and without disabilities (Clements & Nastasi, 1999; Huting, Johanson, & Rippey, 2000; Nastasi & Clements, 1991). Children can improve conflict resolution abilities and self-directed problem solving abilities as well as develop their meta-cognitive capabilities in a computer-supported educational setting (Clements & Nastasi, 1999). In a 3-year collaborative study involving 698 three- to five-year-olds, researchers explored the effects of a comprehensive technology system. Of the 698 children, 317 had disabilities, and 44 of these were investigated in depth. The major finding of the study was that computer applications resulted in a) easier access to the general curriculum, b) increased self-esteem, and c) improvement in social, fine, and gross motor skills, self-help, communication, and emotional and cognitive development. Moreover, teachers reported that in comparison to other activities, computers kept the children's attention for a longer time period (Huting, Johanson, & Rippey, 2000).

There are only a few studies involving the use of technology to teach mathematics in early childhood education and early childhood special education (Fuchs et al., 2006; Wilson, Majsterek, & Simmons, 1996). A recent study provided evidence for the efficacy of a mathematics curriculum that combines research-based mathematics software with other manipulative and printed material. This study involved 68 students aged between 34.8 and 57.8 months old who were attending preschool programs that served low-income families. At the end of the school year, students in the

experimental group had significantly improved their mathematical skills in the areas of oral counting, subitizing, sequencing, and shape identification. It was reported that the students who had received the treatment also began to use more sophisticated numerical strategies (Sarama & Clements 2006). Computer-assisted instruction (CAI) was also found to be effective for first-graders considered at risk for LDs (Fuchs et al., 2006). After 18 weeks of CAI on number combinations, the experimental group considered at risk for LDs improved considerably in addition fact retrieval measures.

However, there are a few concerns when evaluating this group research and the practical use of computers in the classroom. The first issue is the inadequate description of the specific technological math interventions in these publications (Wilson et al., 1996). Previous research using control groups to demonstrate the greater effectiveness of computers over other instructional techniques is limited (Fuchs et al., 2006; Hasselbring & Tulbert, 1991). Although computers are used in many kindergartens, information on whether they are utilized in developmentally appropriate ways in high-poverty schools is dubious (Judge, Puckett, & Cabuk, 2004). In classrooms, teachers are responsible for conducting and supervising several activities that are happening concurrently. This creates challenges for overseeing a child working on a computer. However, adult assistance increases the benefits of computers (Cohen, 1990). One possible way to overcome this limitation is to involve parents when using computers as an educational tool.

The Role of Parents

Parental participation in children's mathematical activities plays an important role in children's future mathematics achievements (Landerholm, 1994). Furthermore, Whiting (2004) suggests that when mathematical activities expand from the classroom into children's homes, children increase their self-confidence and have a better chance to engage in additional mathematical discourse.

Including a parent as a more experienced partner in a mathematical activity is consistent with the socio-cultural theory of learning. One of the central themes of the socio-cultural approach is the use of tools and signs that mediate mental functions (Coulal, 2002; Hung & Nichani, 2002). With the help of computers as a cultural tool, children's mathematical learning can be mediated. Parents are successful tutors since they work in the zone of proximal development (ZPD), adapting and modifying information based on the child's needs (Bjorklund, Hubert, & Reubens, 2004; Mattanah, Pratt, Cowan, & Cowan, 2005).

The Purpose of the Study

Derived from the ideas mentioned above, a 12-week home-based intervention was developed. A software program called *SRA DLM Math Pre-K Building Blocks* has been chosen for the participating parent-child teams to use as an instructional tool in order to facilitate the number-sense development of young children considered at risk for LDs. As it was mentioned earlier this study was designed based on the principles of socio-cultural approach, which employs a broader outlook toward education. When studying children's learning, this theory draws attention to the importance of individual, interpersonal, and cultural-historical factors as much as to the specific academic skills that need to be taught (Bjorklund et al., 2004; Massey & Walford, 1998).

Accepting that learning happens in a social context brings a greater complexity to educational research. Unlike other scientific inquiries or earlier psychological and educational research conducted in well-controlled laboratory-like settings allowing for precision in measurement (Bjorklund et al., 2004), a researcher studying youngster's mathematical learning in a naturalistic setting, encounters many different pleasurable and exasperating situations. Therefore before undertaking the actual study, it was necessary to do a pilot study in real homes in order to test the software and the testing materials, to develop better understanding of the children's and parents reactions to the research, to finalize written materials (such as parent checklists) and to be better prepared for the possible situations that may come up during the actual study.

The purpose of this study was to answer following two main questions:

- 1) To understand whether frequent use of CBMs causes increased scores in the four subtests of the CBM because of the practice effect.
- 2) To evaluate the efficiency of the computer-supported early mathematics intervention program designed to be used at home. Specifically:
 - i. Will computer use with parent scaffolding accelerate the development of number sense skills in participants?
 - ii. What type of issues will arise during the actual study in relation to measures and software use?
 - iii. What are the parent participants' thoughts concerning the intervention?

Method

A multiple-baseline across participant design was chosen to examine the effects of using the SRA DLM Math Pre-K CD-ROM in combination with parent scaffolding on the number sense skills of young Turkish children. The characteristics of parent and child participants, study settings,

test and intervention materials, data collection and analysis procedures are described in this section. Additionally, semi structured parent interviews conducted before and after the study. Each interview lasted thirty to forty minutes.

Participants

Participants included two mother-child dyads. Each participant was given a pseudonym.

Dyad 1: Sevim-Murat. Murat is a four-year-old boy who attended a half-day Head Start classroom last year. Sevim is 30 years old. She has a BA in early childhood development from a university in Turkey. She worked for a few years as a day care teacher in Turkey. Sevim also has a seven-year-old son. Sevim is currently a homemaker; however, she also works from home as a seamstress and prepares desserts for a restaurant.

Dyad2: Elif-Fatih. Fatih is a four year-old boy who attended the same Head Start classroom with Murat the previous year. Elif is 27 years old. She has a BS in geography education. She moved from Turkey to the U.S. right after graduation without having the chance to work as a teacher. Currently, Elif is a homemaker. Fatih has a 2.5 year old sister. Fatih had some medical problems and was in the hospital for a short time when younger. He also had impairment due to cleft feet. It was also recently discovered that he had a severe vision impairment, which was corrected with prescription glasses.

Participant selection was based on the following criteria:

- a) First, each mother should agree to work with her child for 20 minutes per day, three days a week for a one month period.
- b) Both child participants should attend the same Head Start classrooms since participants for the larger study will be selected from Head Start sites in the same town.
- c) The children should be born in the U.S. in 2002 and use English as a second language.
- d) Neither child should have an uncorrected visual or hearing impairment.
- e) As reported by the mother, each child should be able to use a computer mouse and follow simple directions.

Setting

Both children were in Head Start classrooms and neither received special education. In order to conduct the tests, the researcher visited each participant in his home. The participant sat at a table across from the researcher when receiving the CBMs and Building Blocks Assessments. The child had an assessment paper in front of him and the researcher had a stop watch as well as a copy of that session's CBM in front of her in order to complete the markings. During the CBM testing, the participant's siblings were asked to leave the room or were asked to be an "invisible person"

and sit somewhere in the room where the participant could not see them. Each participant worked on the software in his home at the computer desk. During the intervention, the mother sat next to her child at the computer.

Dependent Measures

Building Blocks Assessment. This assessment was used as a pre-test and post-test tool for these purposes: a) to demonstrate change in participants' mathematical abilities and b) to validate the results acquired via weekly CBMs.

Mathematical Curriculum Based Measure (M-CBM). CBM was used three times a week as a measure of progress.

Parent Interviews. Both mothers were interviewed at the end of the study regarding their thoughts about the intervention and mathematics education in general.

Intervention Materials

Materials included the following: a) a software program called *DLM Building Blocks*, b) handouts for parents explaining the game and game levels, c) parent checklists, and d) a mystery bag containing prizes to reward the children for participating.

Pilot Study: Part A

One week before the actual pilot study began; the CBM was piloted on Murat in order to understand whether frequent use causes an improvement in a child's number sense skills. He received only CBMs three times a week for two weeks. The last week of Part A was to be considered the first baseline week of Part B of the pilot study.

Pilot Study: Part B

Experimental Design

A multiple baseline design was used in order to evaluate the effects of the computer-supported home-based intervention on the number sense skills of two four-year-old children. Each parent-child dyad was placed on a different schedule. The pilot study lasted four weeks. Experimental phases included baseline and computer-supported math intervention.

Procedure

Baseline Testing. During baseline, each student received CBM three times a week in order to evaluate their performance on number sense skills before the intervention. While Murat's baseline phase concluded at the end of the first week, Fatih stayed in this phase for three weeks.

The pilot study was originally planned to include another mother-child dyad which was to begin the intervention after two weeks of baseline testing. This dyad was going to start receiving intervention at the end of the second week; the child was going to be in the baseline one week more than Murat. Meanwhile, Fatih was to be the third in line to start the intervention. Unfortunately, this dyad dropped out after they were introduced to the software during the third week. Because of a change in participants, Fatih began receiving the intervention two weeks later than Murat.

Each baseline testing took 20 minutes. During baseline, the researcher provided verbal praise after the student completed the test.

Intervention. Next, the participants were introduced to the software one at a time.

As they worked on the software with their mothers three times a week, they were also assessed three times a week by the researcher using a CBM. Each week the researcher chose a different game for the parent-child dyad to work on. The researcher also set the difficulty levels for the activities; however, the parents were encouraged to change the level (not the activity) based on their child's performance.

All instructional sessions were held at the participants' homes with the mothers. Each instructional session lasted 10-20 minutes. The researcher explained to parents that they could use a combination of the following strategies: a) prompting to start the activity, b) prompting after error, c) positive verbal feedback, d) instruction, and e) modeling. The mothers were encouraged to call the researcher if they had any problems or questions about the intervention.

Murat began the intervention during the second week of the pilot study by working on an activity titled *Double Trouble*. During the third week, he and his mother worked on the activities titled *Party Time* and *Dinosaur Soup*. During the fourth week, they played *Build Stairs* and *Memory Number*. Fatih moved to the intervention phase in the fourth week, during which he and his mother worked on *Double Trouble* and *Party Time*. During the third week Sevim completed the parent check list, and Elif did so during the fourth week.

Results

Results for Pilot Study: Part A

Before the actual pilot study began, the CBM was piloted with Murat for two weeks to see whether the frequent use of this measure caused an improvement in children's number sense test scores.

The first purpose of piloting the CBM was to understand whether the frequent use of the CBM increased scores in the four subtests of the CBM because of the practice effect. Figure 1

presents the number of correct responses provided by Murat over a two-week period while he was receiving only the CBM three times each week.

His mean number of correct responses during the first week was 9.6 in oral counting, 11.33 in number identification, 6.66 in quantity discrimination and 0.33 in missing number. During the second week of piloting the CBM, his mean scores were 10 in oral counting, 6.3 in number identification, 7 in quantity discrimination and 0.33 in missing number.

The graph in Figure 1 illustrates that his subtest scores remained consistent in oral counting (he always counted up to 10, with the exception of one session) and missing number (with the exception of 2 sessions in which he could not find the missing number) while his subtest scores in quantity discrimination and number identification fluctuated. In other words, during these two weeks he did not show a steady increase as a result of the practice effect.

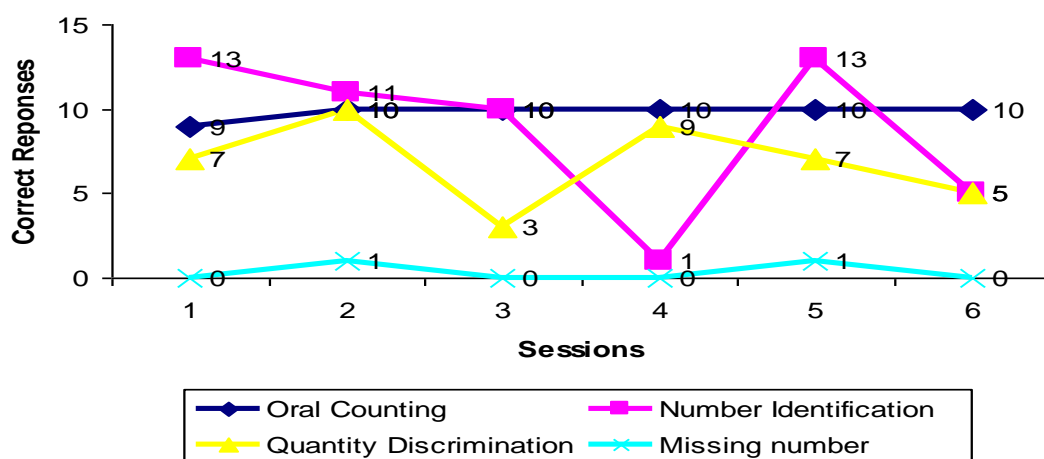


Figure 1: Impact of Frequently Administered CBMs on Murat's Number of Correct Responses in Oral Counting, Number Identification, Quantity Discrimination, and Missing Number Subtests.

Results for Pilot Study: Part B

The second part of the pilot study was conducted in order to evaluate the effectiveness of the SRA DLM Math Pre-K CD-ROM in combination with parent scaffolding with regard to the two child participants' number sense skills. Figure 2 illustrates the impact of the intervention on number identification skills, while Figure 3 illustrates the change in participants' quantity discrimination skills.

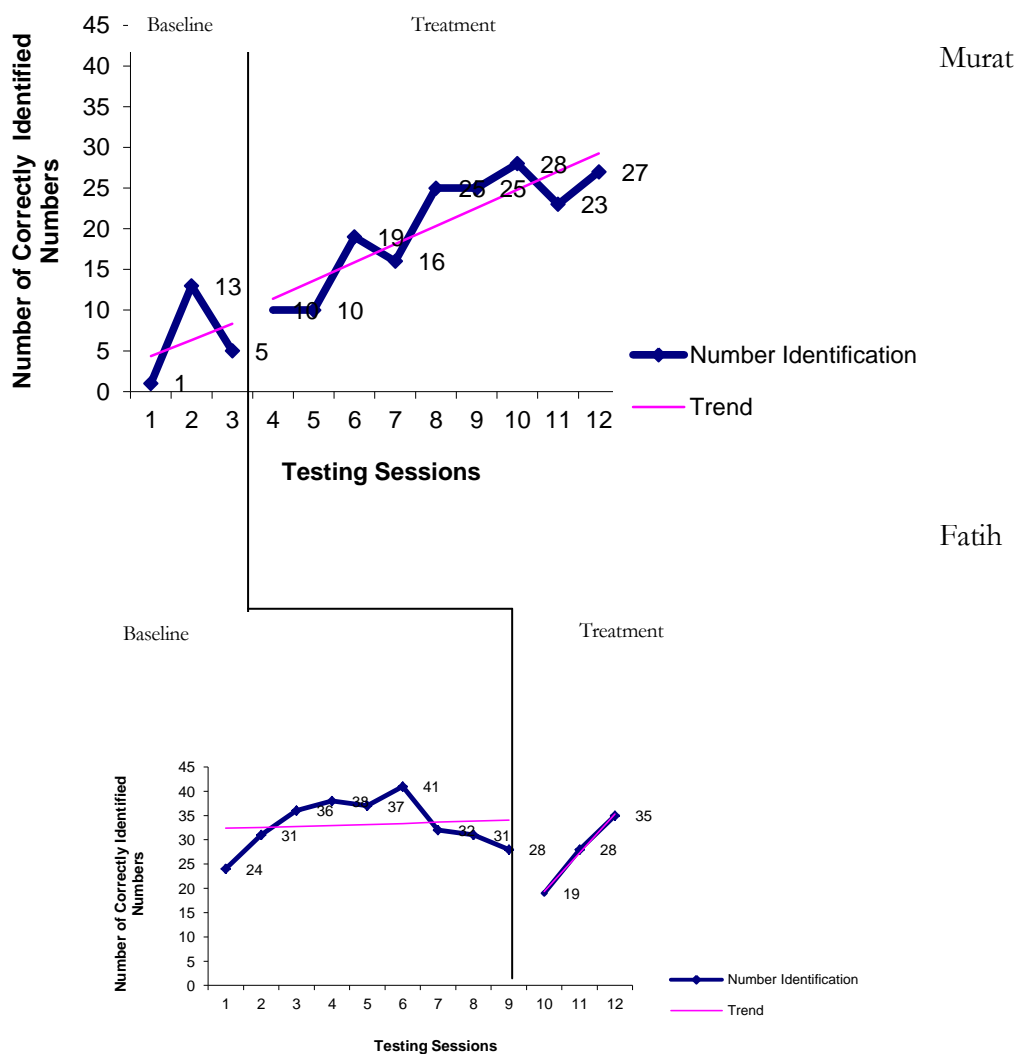


Figure 2: Number of Correct Responses in the Number Identification Subtest of the CBM during the Baseline and Intervention Phases for Two Participants.

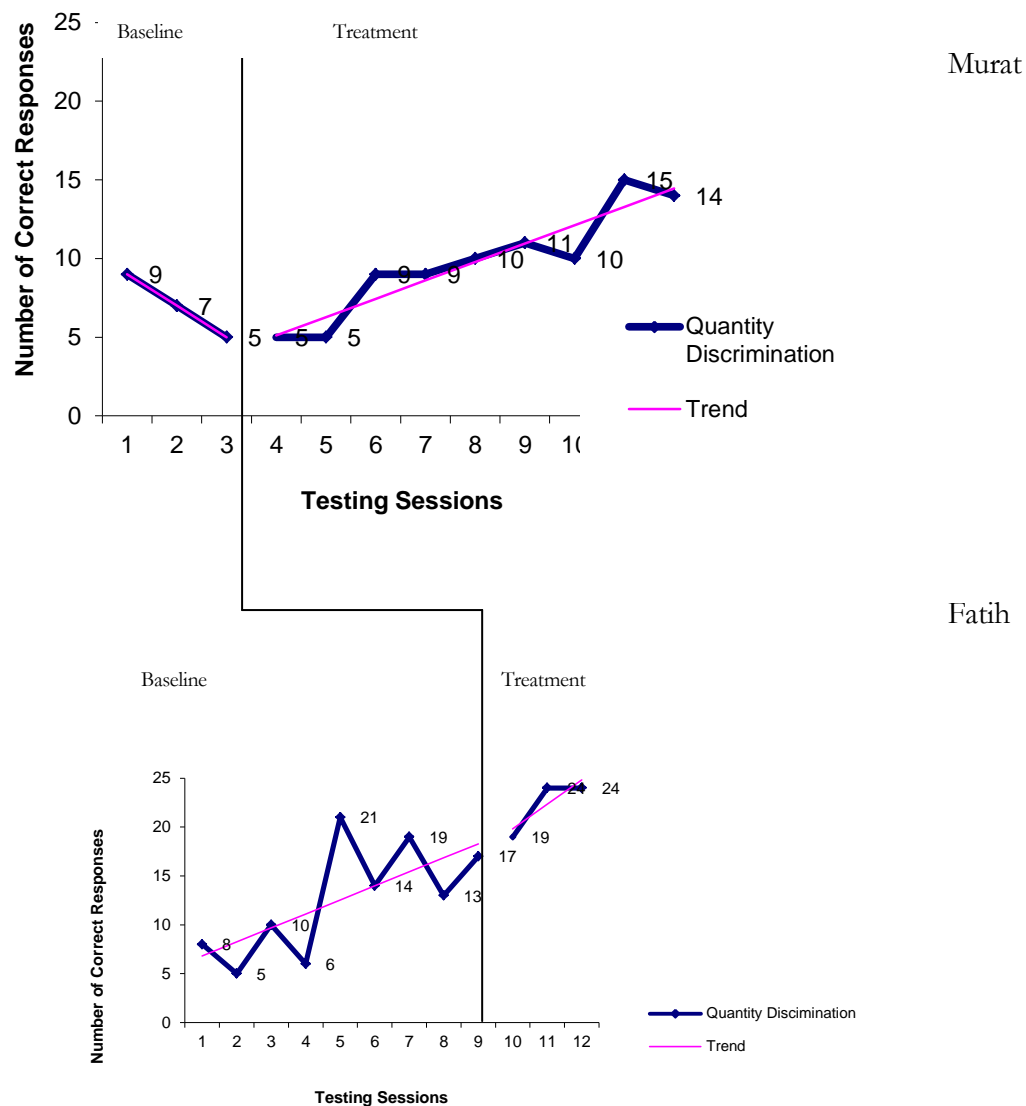


Figure 3: Number of Correct Responses in the Quantity Discrimination Subtest of the CBM during the Baseline and Intervention Phases for Two Participants.

A visual inspection of Figures 2 and 3 reveals that after only two instructional sessions on the computer with his mother, Murat was more successful in identifying and discriminating between numbers. His mother also reported a change in his attitude while working on the computer. When Murat first began the intervention, he would simply try his chances without carefully listening or thinking about what had been asked. He became bored after 7-10 minutes. According to Sevim, after working with him for a week, Murat started to provide a rational for his selections and began to use certain strategies. For example, after the intervention, instead of clicking on a cookie to see whether it was the right answer, he would use his fingers to count the

chips on the cookie first and then count the chips on the possible answers. After he found the same number of chips on the cookie in the question, he would answer. Furthermore, Sevim was excited that Murat was paying better attention and sometimes even working more than the required time. Her excitement was evident; after each instructional session Sevim called the researcher to tell about how Murat had done on that day's activities. Thus, it was apparent that Murat's improvement in the computer activities also had a motivating impact on his mother.

At the beginning of the study, Fatih's baseline scores in both areas were much higher than Murat's. While Faith's scores on quantity discrimination continued to have an increasing trend during intervention, his scores on number identification initially dropped but then increased. On average, his scores in number identification were lower than they were during the baseline phase. His mother Elif explained that the computer games he normally played were much livelier and colorful than the software used for the pilot study. During the interview, Elif mentioned that sometimes she had to convince him to work on it and that most of the time he did not need any help answering the questions asked by the software. Figure 4 summarizes the general impact of the intervention on participants' CBM scores.

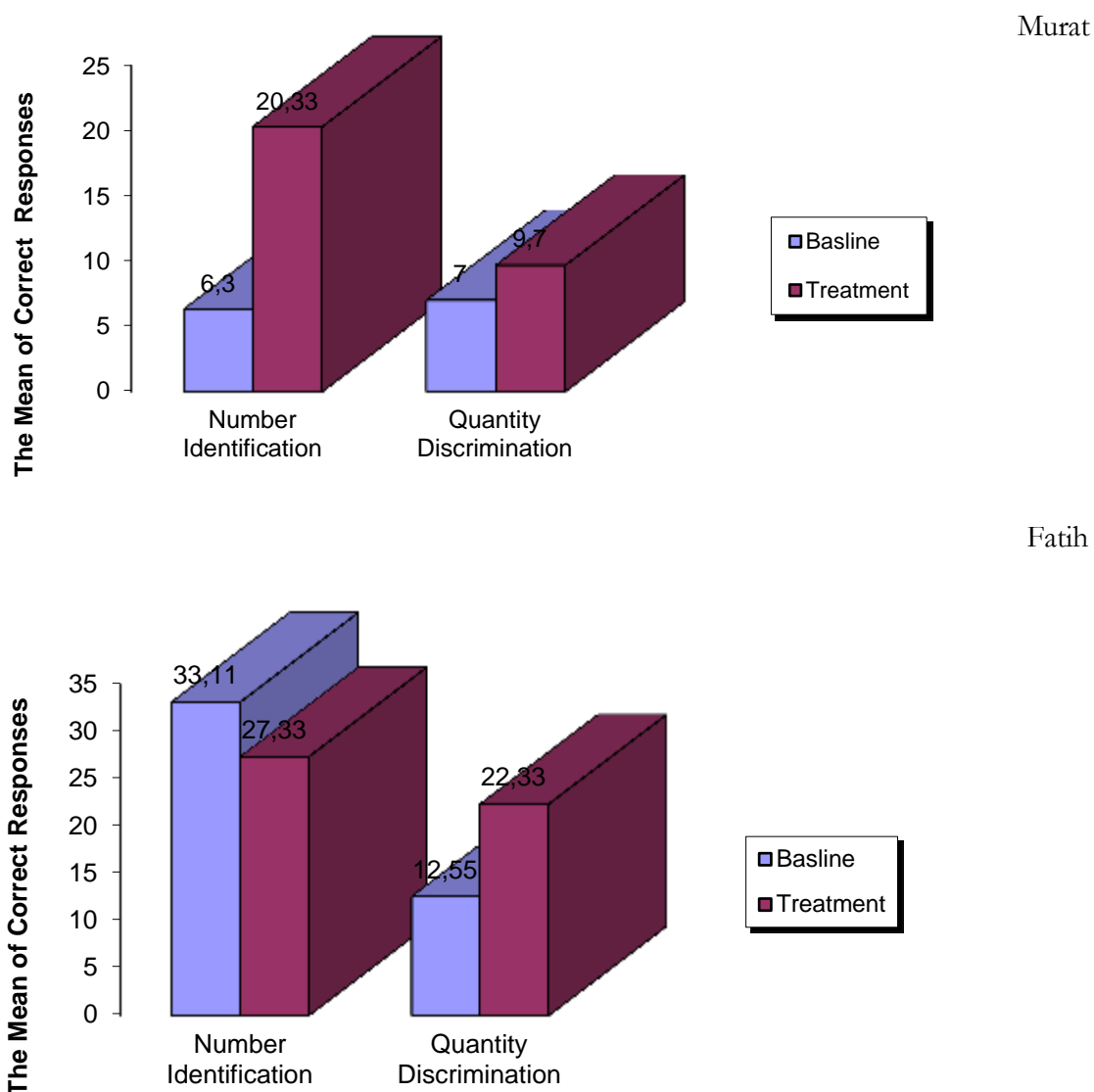


Figure 4: Two Participants' Mean Correct Responses for the Number Identification and Quantity Discrimination Subtests of the CBM during Baseline and Treatment.

Figure 4 illustrates that during baseline, Murat's mean scores were 6.3 and 7 for number identification and quantity discrimination, respectively. After the intervention was introduced, Murat's mean scores increased to 20.33 and 9.7, respectively. In comparison to the baseline phase, Fatih also demonstrated an increase in mean scores for quantity discrimination during the treatment phase. His average score increased from 12.55 to 22.33. However, in the area of number identification, Fatih's mean score dropped from 33.11 to 27.33.

The second purpose of conducting the pilot study was to detect potential issues that might arise during the actual study in order to develop measures against them. The first issue detected concerned the parents' desire for their children to do well on the test. It was very important to explain to the parents the rationale of the baseline phase. The parents needed to understand that even a small amount of help would detract from the validity of the intervention. The mother participants appeared worried when they learned about the testing. They were concerned that their children might not do well on the CBM. An effective way to help parents with these feelings and prevent them from instructing their children during the baseline phase was to explain to them that their children would not be compared with other children. It also helped them to know that they would be able to see their children's improvement by comparing their performance before and after the intervention. When parents saw their child's improvements, they became more motivated.

Toward the end of the second week, it became clear that the children had begun to lose their motivation to complete all four subtests of the CBM. It was also clear that their attention was dwindling toward the end of each session. To prevent these two problems, a "mystery bag" was introduced during the second week of the pilot study. In preparing this bag, the parents were consulted. Based on the mothers' suggestions, the bag was filled with candies, toy cars, pencils, and other toys. The bag's contents changed every week. The children were allowed to pick one surprise from the mystery bag as soon as they finished the CBM. The mystery bag was included in the actual study due to its success. During the actual study, a token economy can be set up to prevent saturation.

In addition, after the ninth session, the researcher decided to use only two CBM subtests, number identification and quantity discrimination. After this session, the children did not receive the oral counting and missing number subtests. When the child participants realized that the test was shorter, they were able to pay better attention to the two remaining subtests. The mothers also confirmed the advantages of reducing the subtests from four to two.

Although each of the four subtests lasted only for a minute, the actual application could take longer than four minutes. If the tests were done at home, 15-20 minutes needed to be put aside due to the time necessary for the child to calm down and for parents to provide explanations, directions, and administer practice pages in addition to the four minutes of actual test time. The time necessary to complete the subtests decreases as sessions are completed because the children become accustomed to taking the test and learn the directions.

Another lesson learned from the pilot study was the best way to administer the test sessions. It was most effective for the researcher and the child to sit right across from each other at a table. The researcher needed to know the test very well and not pause to recall or to read

directions. The directions needed to be clear and consistent each time. Administering the test in this way not only helped the children understand the testing rules and comply with them, but also prevented other siblings in the house from disturbing the testing session.

The third goal of the pilot study was to understand the mother's thoughts concerning the intervention. Both Sevim and Elif stated that they enjoyed taking part in the study. Sevim commented:

I was working with Mehmet (Murat's older brother) when he was at Murat's age. His dad too... We would teach him math and read with him more. But I have not done it with Murat. I want to though. I planned on putting aside an hour every day this summer to work with both of them... But this [intervention] gave it a structure; we had to work at least three days... I was also feeling guilty that I was not able to spend one-on-one time with Murat. This way we get to do that too.

The mothers mentioned that having a schedule both for testing and for instruction was helpful. Elif shared:

When you come Monday, Wednesday, and Friday afternoons, we know we have to work at least before you come. Otherwise [when we give you a call when we are available] it kind of gets lost among other daily things. For example, I planned on working yesterday, and then Nihal came over with her kids. We went to the park, when we come back home, Fatih was already so tired...

While both mothers agreed about the benefits of scheduling the tests in advance, Sevim and Elif had conflicting views concerning the software. Sevim and Murat liked the activities provided by the software. Sevim explained that although Murat was ambivalent about *Double Trouble*, he greatly enjoyed the other activities. While he was not able to focus for more than 10 minutes in the beginning, toward the end he was able to work 20 to 30 minutes on some days. It was obvious that Sevim felt proud of him as the study progressed. During the first sessions, she expressed her worries that he was behind his peers; toward the end she focused on how meaningfully he answered the questions on the computer and how much his attention span had improved. She also began to have better insight into which questions he was able to answer and why. She provided a detailed verbal report on each week's activities and asked questions about the general development of number sense skills. In contrast, Elif mentioned that the software was somewhat dull and that Fatih did not want to play with it. She mentioned that the activities were simple for Fatih and too repetitive.

Furthermore, Sevim and Elif's ideas about when to start teaching mathematics were also different. Sevim felt accountable for what she perceived as Murat's weak mathematical skills and for not teaching him systematically. Elif thought that Fatih was learning when he was playing on the

computer and watching television. Although she thought that mathematical training would increase Fatih's academic abilities, she did not feel that formal mathematics instruction was necessary at this age.

Conclusions & Discussion

Two parent-child teams participated in the research were low income families. Although both mothers had a bachelor's degree, they were unemployed at the time of the study. Many researchers have noted the significant achievement gap between low- and middle-income families in mathematics (Esposito, 2003; Griffin et al., 1994; Jordan, Kaplan, Olah, & Lacuniak, 2006; Klein & Starkey, 2004). Results of a longitudinal study reveal that although the overall rate of improvement in selected mathematical skills was similar for middle- and low-income families, at the end of the year children from lower socioeconomic backgrounds still trailed behind in mathematical skills learned outside the school environment (Jordan et al., 2006).

The results of the pilot study indicated that young children can be taught at home by their parents and improve their mathematical skills via technological devices. In this study, Murat's performance substantially improved after the intervention in both subtests of the CBM. However, similarly significant effects on Fatih were not seen, especially in the area of number identification.

It was observed that administering all four subtests three times a week caused fatigue and boredom for the pilot study participants. The number identification and quantity discrimination subtests were chosen over others for the following reasons: a) the developers of the tool reported that reliability of the number identification and quantity discrimination measures were constantly high and had a mean score of .90, a fact that made these tools appropriate for making educational decisions; b) the oral counting and missing number measures were less reliable compared to the number identification and quantity discrimination subtests; and c) the quantity discrimination measure was found to be a good measure of early mathematics and had the highest predictive validity (Clarke & Shinn, 2004).

Although the results of the CBMs and the interviews with the mothers reveal encouraging outcomes for this type of the intervention, the nature of the design used in this pilot study indicates that interpretation of findings requires caution. Because one of the three dyads dropped out of the pilot study, it is difficult to make inferences based on data collected from only two subjects. However, this pilot study was helpful in terms of identifying possible problems that may occur in the actual application of the study. Based on responses from the mothers and children, the duration of the instructional sessions dropped from 20 minutes to 10, the length of the CBM testing was

shortened, a mystery bag was introduced, and a parent checklist was developed or treatment fidelity.

Additionally, another study used the same software and the same assessment tool, the DLM Building Blocks Assessment (Clements & Sarama, 2007), in order to test the efficiency of a pre-school mathematics program designed around the research-based SRA DLM Math Pre-K CD-ROM and print curricula. The researchers worked with a group of 68 children who came from low-income families. Their results demonstrated that the experimental group increased significantly more than the comparison group, who only received the regular curriculum for a year. The largest gains were found in subitizing and sequencing (Clements & Sarama, 2007).

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